Multi-Agent, Multi-Attribute Policy Models:
Reflecting a Dynamic Marketplace in the Adoption of Green Power Technologies

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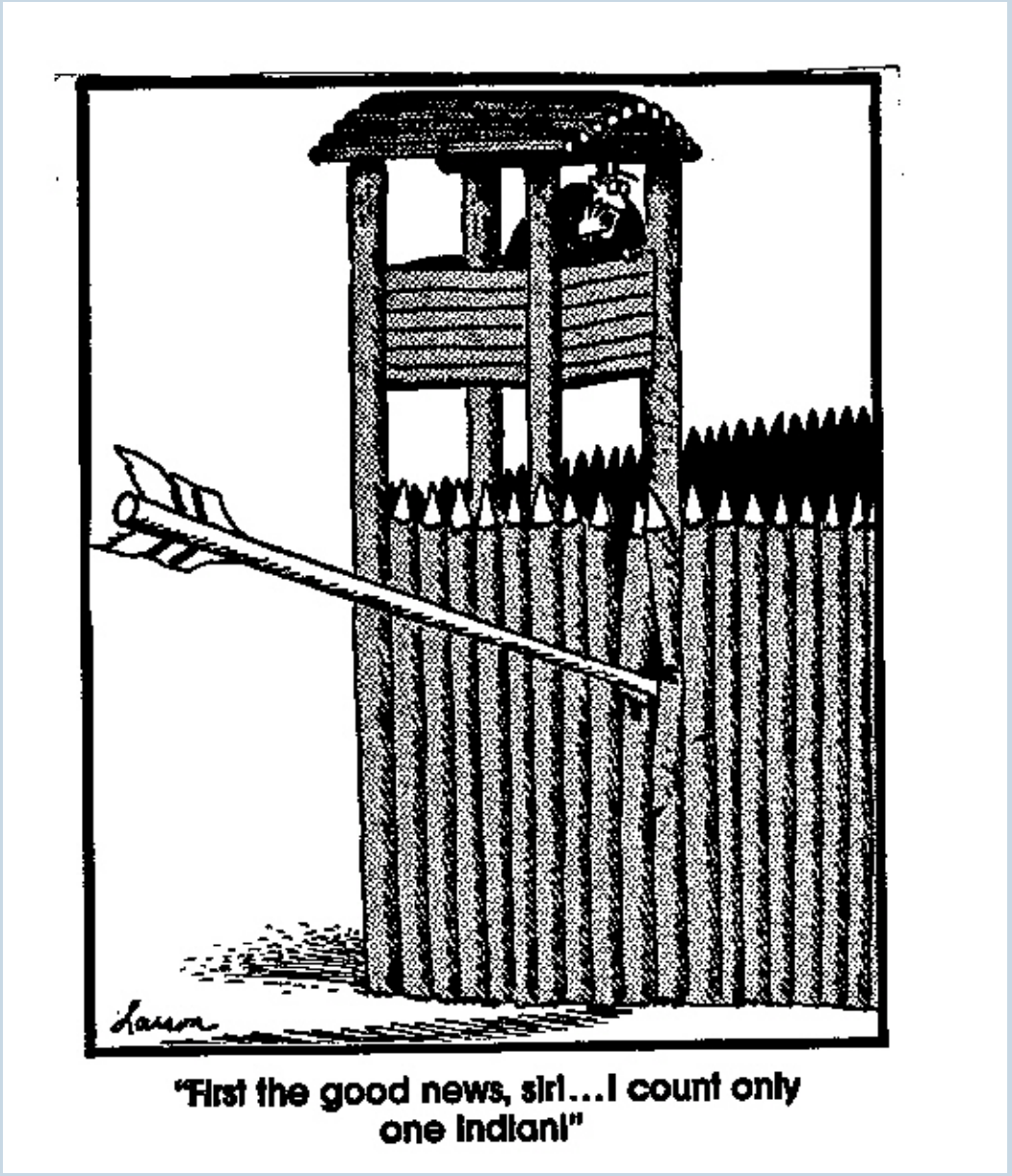
A Philosophical Overview

The record of US model-based energy forecasting yields evidence that such models provide biased estimates which tend to reinforce the status quo of current market structure, inadequately inform policy-makers about new market potential, and serve to constrain the development of innovative technologies and policies. This presentation explores several potential limitations within electricity supply models. It then explores the extent to which energy-economic models might reflect a more dynamic behavioral and technological diffusion process that encourages new policy development.

Would this necessarily be true? Where the fort might symbolize the gathering of clean energy technologies, and where the single (but admittedly very big) arrow had been launched from an inappropriate market characterization of the U.S. economy?



Some Additional Perspectives

Economics Science Has Not Solved. . . .

. . . . its very first problem — namely, what determines the price of a commodity?

UK Economist, Joan Robinson, 1947

Among the Things that Influence. . .

. . . the price of a commodity or a technology, are:

- Belief
- Value
- Habit
- Alternatives
- Necessity
- Income

- All of which can be shaped by perception, policies, and programs.
- To the extent that policy models overlook these influences, they may limit the evaluation of meaningful alternative policies or technologies.

Motivation for this Work

- Since the mid ‘90s, there has been an acceleration of work on the influence of technological change in energy modeling and climate analysis.
- In general, the findings to date indicate that improved representations of technological change − both “endogenous/induced” and learning-by-doing (LBD) − may have substantial implications for estimating costs and benefits of energy and/or pollution abatement policies.
- However, the work to date has focused more on the cost characterization of technologies with little attention to the marketing and behavioral characterizations that also influence the adoption of new energy technologies.
- The heuristic model described in the next set of slides is intended to determine whether standard energy policy models might reflect a more dynamic behavioral and technological diffusion process that encourages new policy development.

About the Heuristic Model

The Overall Analytical Framework

- The heuristic model is a Monte Carlo simulation that evaluates and selects a mix of four competing technologies which might be required to meet the growth in electricity demand, and to replace retired generating units — all in some future year (call it 2012).
- However, rather than assume a single "representative agent" to choose the technologies, we allow 100 different agents (whether firms or households that different preferences) to choose within a random pattern of influences affecting their choice.
- Among the influences on technology selection are price (of course), the assumption of a general familiarity with the emerging technologies, an awareness of non-energy benefits, and finally, some level of value for market externalities or air pollution reductions.

Several Important Caveats

- The focus of the analysis that follows is on the influence of both price and non-price market drivers as they may affect technology choice — not on the actual characterization of any individual technology or energy scenario.
- All values or attributes in this exercise are expressed in $/kWh for comparative purposes and ease of use. A more rigorous modeling exercise would also include financial hurdle rates, substitution and income elasticities, revealed preferences, and the influence of networks, advertising, standards and other market drivers.
- An entirely different set of assumptions, or range of assumptions, would produce an entirely different set of results.
- There is no specific policy or emission targets implied by any of the analysis that follows.
- Finally, while the analysis does provide useful insights into understanding the market potential of renewable energy or green power technologies, in many cases the data do not yet exist to properly reflect the many factors that might influence consumer and business decisions.

Illustrative Parameters for One Set of Runs
(with critical values expressed in $/kWh)

Technology	Cost	Benefits	Awareness	See Others	Externalities
Defender	0.040	0.000	0.000	0.000	0.000
Challenger	0.060	0.004	0.002	0.002	0.004
Renewables	0.080	0.015	0.008	0.008	0.008
Efficiency	0.060	0.012	0.004	0.004	0.010
Range of the Value Influence					
Lower Range	80	40	0	40	70
Upper Range	100	80	1	80	95

Market Share Algorithm

$$MS_{kt} = \frac{COST_{kt}^{-v}}{\sum_{k=1}^{J} COST_{kt}^{-v}}$$

Where:

MS_{kt} = market share of technology k at time t

$COST_{kt}$ = amortized capital and operating costs (net of benefits and/or incentives) of technology k at time t

v = variance parameter representing cost homogeneity

J = number of technologies competing to provide the same service as k.

Explaining the Variance Parameter

- For the variance parameter, *v*, an extremely low value, such as 1, means that new equipment market shares are distributed almost evenly among all competing technologies, even if their annual costs differ significantly.
- An extremely high value, such as 10, means that the most cost effective equipment gains a proportionately higher market share.
  - For example, a technology with a 25 percent cost advantage would grab 90 percent of market share.
- In this exercise, we adopt a value of 4.
  - In this case, a technology with a 25 percent cost advantage would grab 71 percent of the market share.

Illustrative Scenario Impacts

Exploring Market Share
(Based only on Cost Parameters)

Technology	Cost Only No Efficiency	Cost Only w/Efficiency
Defender	79.4%	68.6%
Challenger	15.7%	13.6%
Renewables	5.0%	4.3%
Efficiency	0.0%	13.6%

Note: Perhaps one way to help us understand these results is to think of the market share as the contribution of each technology in meeting an estimated 100 billion kWh of new electricity demand in some future year.

Exploring Market Share
(Including an Increased Technology Awareness)

Technology	Cost Only No Efficiency	Cost Only w/Efficiency	Greater Technology Awareness
Defender	79.4%	68.6%	65.6%
Challenger	15.7%	13.6%	14.0%
Renewables	5.0%	4.3%	5.2%
Efficiency	0.0%	13.6%	15.2%

Exploring Market Share
(Now Adding Information Programs)

Technology	Cost Only No Efficiency	Cost Only w/Efficiency	Greater Technology Awareness	Better Demonstration & Information on Benefits
Defender	79.4%	68.6%	65.6%	52.1%
Challenger	15.7%	13.6%	14.0%	14.1%
Renewables	5.0%	4.3%	5.2%	8.9%
Efficiency	0.0%	13.6%	15.2%	24.8%

Exploring Market Share

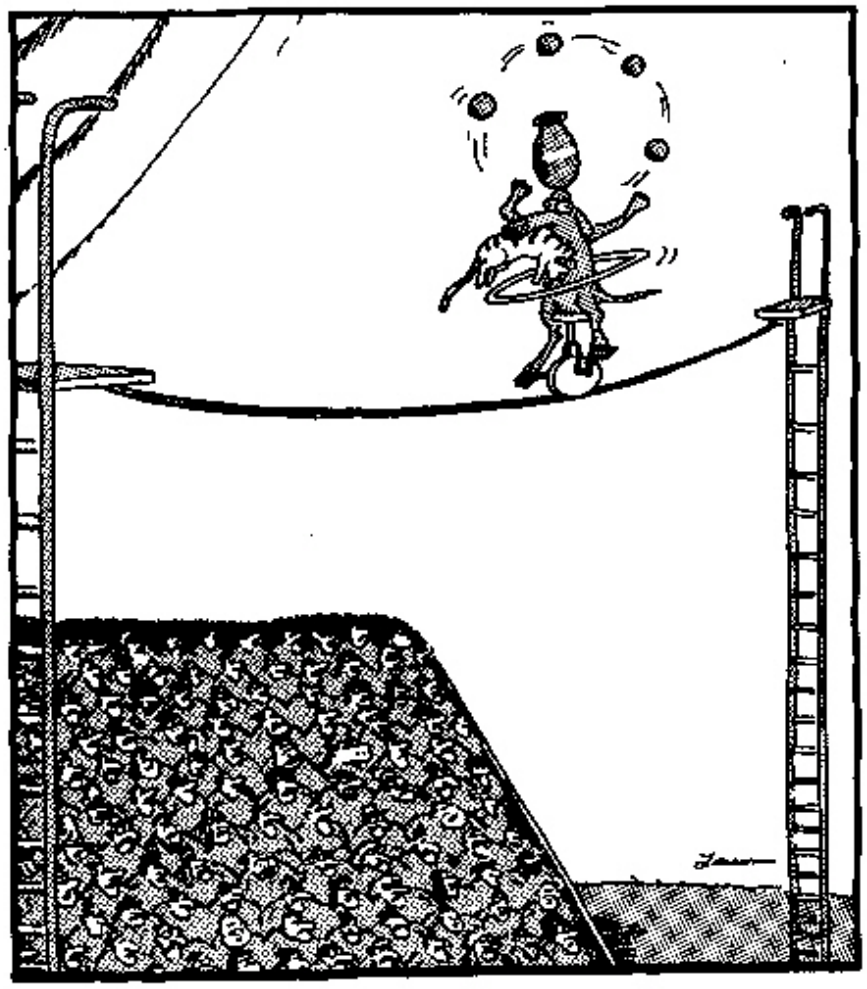
(And Finally, Reflecting Market Externalities)

Technology	Cost Only No Efficiency	Cost Only w/Efficiency	Greater Technology Awareness	Better Demonstration & Information on Benefits	Externalities Reflected in Price
Defender	79.4%	68.6%	65.6%	52.1%	38.5%
Challenger	15.7%	13.6%	14.0%	14.1%	14.4%
Renewables	5.0%	4.3%	5.2%	8.9%	13.0%
Efficiency	0.0%	13.6%	15.2%	24.8%	34.0%

Conclusions

- Modeling exercises that depend only on the cost characterization of technologies may understate market penetration of new or emerging technologies under different price or policy scenarios.
- Perhaps just as important, models that fail to include a richer behavioral backdrop and market characterization tend to reinforce or preserve the status quo rather than provide meaningful insights for policy analysts and decision makers.
- An equally important area of discussion, but one that (in the interest of time) is not addressed here today, is the importance of a more complete accounting of how changed technology investment and spending patterns — including a more complete assessment of benefits and costs — can positively impact the nation's welfare and economy.

And so this question: Are new technology tricks or market characterizations really out of the question?



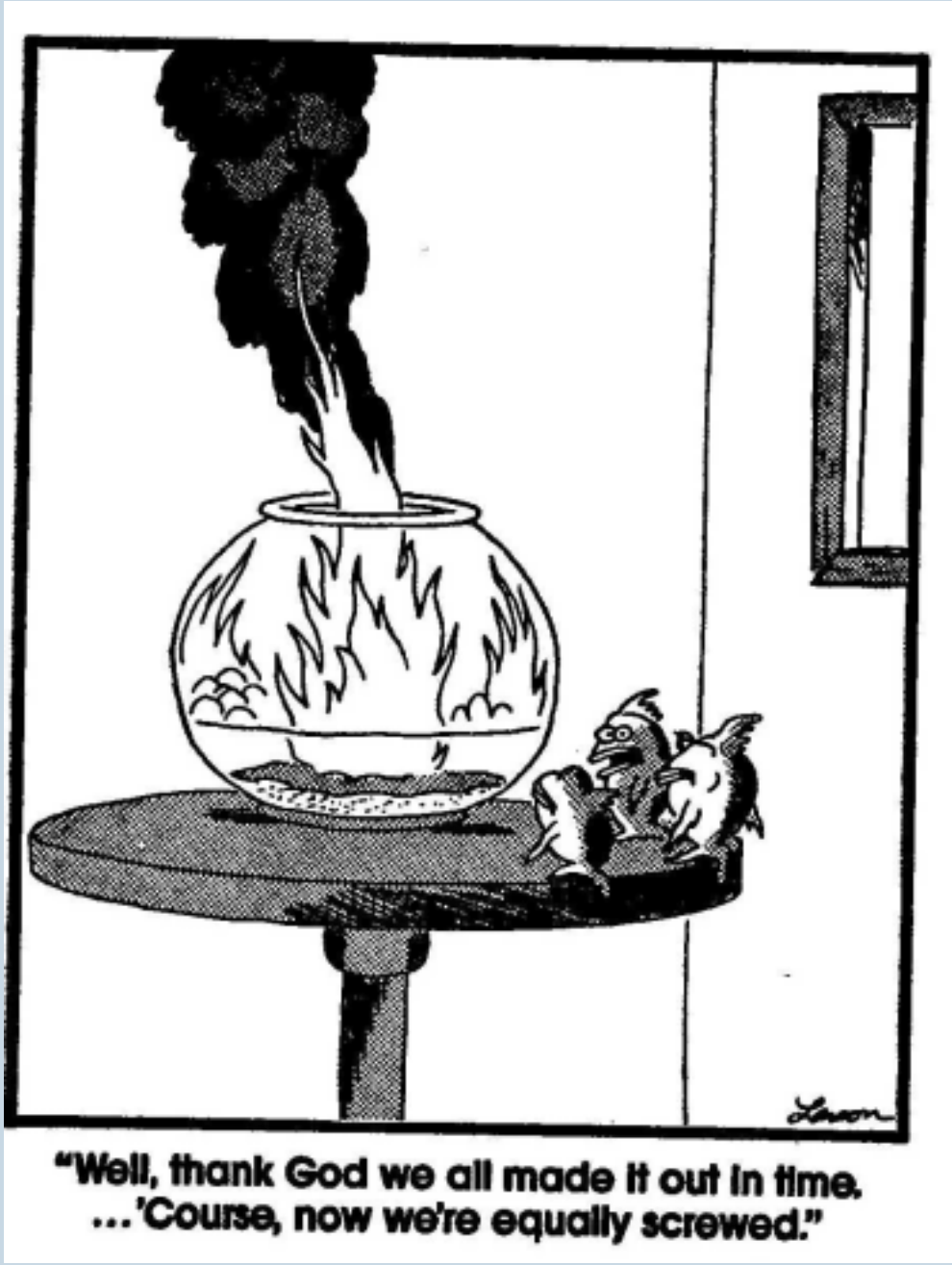
High above the hushed crowd, Rex tried to remain focused. Still, he couldn't shake one nagging thought: He was an old dog and this was a new trick.

The difficulty lies not with the new ideas, but in escaping the old ones

John Maynard Keynes

On the other hand. . . .

Getting the market characterization right may eliminate only one of the many difficulties still ahead. We gotta still deploy those better technologies. . . .



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